

TITLE OF THE INVENTION**WIRE POSITIONING AND MECHANICAL
ATTACHMENT FOR A RADIO-FREQUENCY IDENTIFICATION DEVICE**

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FIELD OF THE INVENTION

10 The present invention relates to radio-frequency identification devices (RFID). More specifically, the present invention is concerned with a wire positioning structure and mechanical attachment process thereof.

BACKGROUND OF THE INVENTION

15 The manufacturing of miniaturized radio-frequency identification devices (RFID) is generally divided in two sequential steps: 1) the winding of an ultra-fine magnet wire (typically 50 μ m to 20 μ m diameter or less) to provide an air-coil – the antenna –, and 2) the subsequent connection of the one or two terminals of the coil to the pads 20 of a microchip.

One of the main difficulties in a mass production process lies in the positioning and in the attachment of the coil wire ends on the standard microchip pads, which typically measure 100x100 μ m or less.

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Traditionally, to avoid this complex operation, the electrical standard pads are enlarged or additional enlarged pads, that measure typically 200x600 μ m, are electrically connected to the small standard

pads. Generally, this large pad insertion requires a microchip redesign and increases the size of such microchip.

Improved wire positioning and mechanical attachment
5 process for RFID are thus desirable.

SUMMARY OF THE INVENTION

The purpose of the invention is to provide means for
10 positioning the coil terminals above the small standard pads of an RFID microchip for electrical connection, and for providing a strong and reliable mechanical attachment between the coil and the microchip.

More specifically, according to a first aspect of the present
15 invention, there is provided an antenna terminal positioning structure for a radio-frequency identification device having an electrical pad mounted on an electronic integrated circuit (IC), the structure comprising:

a wall assembly mounted on the electronic IC and having at
least one wall surface extending from the IC so as to be aligned with a
20 target area on the electrical pad; the target area being sufficiently large to receive an antenna terminal of a radio-frequency identification device;
whereby abutting the antenna terminal against the at least one wall surface allows positioning the antenna terminal on the electrical pad.

25 According to a second aspect of the present invention, there is provided a method for positioning an antenna terminal of a radio-frequency identification device on an electrical pad of an electronic circuit, the method comprising:

providing on the electronic circuit a wall assembly that has at least one wall surface extending from the electronic circuit so as to be aligned with a target area on the electrical pad; the target area being sufficiently large to receive an antenna terminal from the radio-frequency

5 identification device; and

contacting the antenna terminal with the at least one wall surface, while ensuring that a portion of said antenna terminal is at the height of the electrical pad.

10 According to a first embodiment of the present invention, the positioning and the mechanical attachment are obtained by adding a thin layer (about 15µm to 250µm) of attachment material above the microchip protection layer. This attachment layer has a geometry and a placement that allow a precise, stable and fast coil terminals positioning. According to

15 the first embodiment, the attachment material is so chosen so that the attachment layer does not play any electrical part. The electrical connection is made with the small standard electrical pads while the positioning and the mechanical attachment is made with the geometry of the attachment layer.

20 The electrical connection and the mechanical attachment can be made during the same operation or during two distinct operations depending of the microchip and antenna architecture, the electrical connection process and of the attachment process.

25 According to a second embodiment, the wire positioning can be improved by adding a specific positioning structure, made of electrical conductive material, on the small standard electrical pads of such

microchip.

Moreover, the wire positioning structure can be made by a specific design of the electrical conductive material used for the enlarged 5 electrical pads added on some microchips.

Also, the wire positioning can be improved by splitting the small standard electrical pads in two dual miniature electrical pads and adding a positioning structure, made of electrical conductive material, on 10 each part of the dual miniature electrical pads of such microchip. The antenna wire positioning is obtained by the spacing between both parts of the dual miniature electrical pads.

In addition, the positioning structure can be obtained by 15 making a specific topology of the microchip protection layer during the microchip manufacturing process itself, which yields an embedded positioning structure.

Such a positioning structure can be drawn to be used as a 20 optical marks for real time image processing for microchip alignment and positioning in the RFID manufacturing process.

A positioning structure and attachment process according to the present invention is applicable for all RFID microchips whatever are 25 the frequency range and the antenna geometry.

Such a positioning structure and attachment process according to the present invention is also applicable in other micro-

electronic fields like micro-sensors or micro-electronic machines (MEMs).

A wire positioning structures according to the present invention provides a significant tool to improve the image processing cycle,
5 helping to reduce the microchip handling and positioning process and contributing to reduce a product manufacturing cycle time.

Other objects, advantages and features of the present invention will become more apparent upon reading the following non 10 restrictive description of preferred embodiments thereof, given by way of example only with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

15 In the appended drawings:

Figure 1 is a top plan view of a RFID microchip including two terminal positioning structures for a radio-frequency identification device according to a first illustrative embodiment of the present invention;

20 Figure 2 is a cross section taken along line 2-2 on Figure 1;

Figure 3 is a cross section taken along line 3-3 on Figure 1;

25 Figure 4 is a top plan view of a RFID microchip including terminal positioning structures for a radio-frequency identification device according to a second and a third illustrative embodiments of the present invention;

Figure 5 is a top plan view of a RFID microchip including two terminal positioning structures for a radio-frequency identification device according to a fourth illustrative embodiment of the present invention;

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Figure 6 is a cross section taken along line 6-6 on Figure 5;

Figure 7 is a top plan view of a RFID microchip including a terminal positioning structure for a radio-frequency identification device
10 according to a fifth illustrative embodiment of the present invention;

Figures 8A and 8B are cross sections of a RFID microchip including terminal positioning structures for a radio-frequency identification device respectively according to a sixth and a seventh illustrative
15 embodiments of the present invention;

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Figure 9 is a top plan view of a RFID microchip including two terminal positioning structures for a radio-frequency identification device according to an eight illustrative embodiment of the present invention;

Figure 10 is a top plan view of a RFID microchip including two terminal positioning structures for a radio-frequency identification device according to a ninth illustrative embodiment of the present invention;

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Figure 11 is a top plan view of a RFID microchip including two terminal positioning structures for a radio-frequency identification device according to a tenth illustrative embodiment of the present

invention;

5 Figure 12 is a top plan view of a RFID microchip including two terminal positioning structures for a radio-frequency identification device according to an eleventh illustrative embodiment of the present invention;

10 Figure 13 is a top plan view of a RFID microchip including two terminal positioning structures for a radio-frequency identification device according to a twelfth illustrative embodiment of the present invention;

15 Figure 14 is a cross section taken along line 14-14 on Figure 13;

20 Figure 15 is a cross section, similar to Figure 14, of a RFID microchip including two terminal positioning structures for a radio-frequency identification device according to a thirtieth illustrative embodiment of the present invention;

25 Figure 16 is a top plan view of a RFID microchip including two terminal positioning structures for a radio-frequency identification device according to a fortieth illustrative embodiment of the present invention;

25 Figure 17 is a top plan view of a RFID microchip including two terminal positioning structures for a radio-frequency identification device according to a fiftieth illustrative embodiment of the present

invention;

Figure 18 is a cross section taken along line 18-18 on Figure 17;

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Figure 19 is a cross section taken along line 19-19 on Figure 17;

Figure 20 is a top plan view of a RFID microchip including 10 two terminal positioning structures for a radio-frequency identification device according to a sixtieth illustrative embodiment of the present invention; and

Figure 21 is a cross section taken along line 21-21 on Figure 15 20.

DETAILED DESCRIPTION OF THE INVENTION

A terminal positioning structure 10 for a radio-frequency 20 identification device (RFID) according to a first illustrative embodiment of the present invention will now be described with reference to Figures 1 to 3.

Figures 1-3 illustrate an electronic integrated circuit (IC) in 25 the form of a RFID microchip 12 including two conventional electrical pads 14 mounted thereon. Most conventional pads have a dimension of 100 μm x 100 μm or less. However, for some ICs, pad dimensions are 120 x 120 μm).

Each electrical pads 14 are covered by a bump 15 made of an electrically conductive material and being sufficiently thick so as protrude from a protective layer 18 of the microchip 12.

5 Two identical terminal positioning structures 10 are illustrated in Figures 1-3. Each of the structures 10 comprises a wall assembly 16 mounted to the protection layer 18 of the microchip 12. The wall assembly 16 includes two opposite parallel surfaces 20 and 20' each extending perpendicularly from the microchip 12, and therefore from the protective 10 layer 18, so as to be generally aligned with a target area 22 on the bump electrical pad 14.

15 The target area 22 represents a predetermined portion of the bump 15 (or of the pad 14) that should contact with the terminal 24 when the terminal 24 abuts against at least one of the two perpendicular wall surface 20 and 20'.

20 The structure 10 is so configured and so positioned relative to the pad 14 that the surfaces 20 and 20' are aligned with the target area 22.

25 Of course, the target area 22 is only schematically represented on Figure 1, and does not represent any component distinct from the pad 14. The target area 22 is configured and sized to receive a portion of the antenna terminal 24 sufficiently large to provide good electrical contact with the pad 14 via the bump 15 mounted thereon.

.. The terminal positioning structure 10 is made from an

additional layer of attachment material, such as thin film polyimide, deposited onto the microchip protection layer 18. Therefore, the structure 10 allows for both positioning and mechanical attachment of the antenna terminal 24.

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The altitude of the antenna terminal 24 above the microchip protection layer 18 is determined by the design rules, including the spacing D_1 , and by other parameters of the manufacturing process used such as the material thickness h_1 , etching profile etc.

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In operation, the antenna terminal 24 is moved from a first position away from the surface of the microchip 12 that includes the pad 14 to a second position where it contacts at least the surfaces 21-21' of the wall assembly 16 that are parallel to the microchip surface, while 15 ensuring that a portion of the antenna terminal 24 is at the height of the electrical pad 14.

The wall assembly 16 allows to provide an antenna terminal receiving area, defined by the two surfaces 21-21' and their inter-space, which is bigger than the pad 14. As it is commonly known, a user 20 or automatic equipment contacting the wall assembly 16 with an antenna terminal 24 has only to swipe the terminal 24 on the surfaces 21-21' of the wall assembly 16 until the antenna terminal 24 engages the groove formed by the wall assembly 16. The sliding movement of the terminal 24 is 25 stopped when the antenna terminal 24 abuts against one of the two wall surfaces 20 and 20'.

When a portion of the antenna terminal 24 contacts the pad 14, a mechanical attachment is activated between the antenna terminal 24 and the positioning structure using a well-known process such as thermo-compression, ultra-violet (UV) or laser soldering, mono or bi-components gluing etc., depending of the material of the positioning structure 16. In the particular case illustrated in Figures 1-3, UV activation or a laser soldering process can be used since the positioning structure material is made of polyimide material or screen-printed UV glue.

10 This optional attachment process of the wire 24 on the positioning structure 16 can be executed before, after or at the same time of the electrical connection operation of the wire 24 on the small electrical pad 14 via the bump 15.

15 The thickness of the positioning/attachment material may vary from 15 µm to 250 µm depending on the nature of material and of the desired configuration of the positioning structure.

20 The bump 15 can be made of any electrically conductive material such as a noble material, conductive alloy, conductive paste or conductive film etc.

Even though the electrical pad 14 is illustrated as being covered by a bump 15, it can also be bared.

25 The configuration and size of the positioning structure may vary as will be described hereinbelow.

Figure 4 illustrates a RFID microchip 12 comprising two electrical pads 31 and 33 for connecting antenna terminals 24, and two antenna terminal positioning structures 26-28 according respectively to a second and third illustrative embodiments of the present invention.

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Since the structures 26 and 28 are similar to the positioning structure 10, and for concision purposes, only the differences between each of the structures 26 and 28 and the structure 10 will be described.

10

The positioning structures 26-28 comprise respective wall assembly 30-32 mounted to the microchip 12.

15

The wall assembly 30 includes two facing concave surfaces 34 and 34' extending generally perpendicularly from the microchip 12 surface so as to be generally aligned with a target area (not shown) on the electrical pad 31.

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The wall assembly 32 includes two facing skew surfaces 36 and 36' extending generally perpendicularly from the microchip 12 surface so as to define a tapered groove generally aligned with a target area 35 on the electrical pad 33.

25

Each of the two resulted grooves is configured to have multiple cross-sections, which contribute to ease the positioning of a wire 24 therein.

Turning now to Figures 5 and 6, an antenna terminal positioning structure 38 for a RFID device according to a fourth illustrative

embodiment of the present invention will now be described.

Two identical positioning structures 38 are illustrated in Figures 5 and 6. Each of the two positioning structures 38 includes two spaced hemispheres 40, each defining a surface that is tangentially aligned with a target area 22 on a facing bump 15 covering the electrical pad 14.

The positioning structures 16, 30, 32, and 40 can be made of electrical conductive or non-conductive material, since they provide no electrical function. It is to be noted that the antenna terminals do not required to be stripped off to obtain a strong and reliable attachment to these positioning structures.

Figure 7 illustrates an antenna terminal positioning structure 42 for a RFID device according to a fifth illustrative embodiment of the present invention.

The structure 42 comprises a wall assembly 44 mounted to the protection layer 18 of the microchip 12. The wall assembly 16 includes two external rectangular-shaped portions 46 and an internal generally square-shaped portion 48 therebetween. The three portions 46-48 are positioned parallel and are consecutively distanced so as to yields two interspaces, each defining two opposite parallel surfaces 50-50' that are generally aligned with a target area 22.

Since the internal portion 48 is to be contacted with two different antenna terminals 24 (only one shown), for a reliable operation, it

is made from a electrical non-conductive material such as thin film polymide or UV glue etc.

The wall assemblies 16, 30, 32, 40, and 42 define grooves
5 that are adapted to receive an antenna terminal 24 that is vertically set
(following the Z-axis entering the page) onto the microchip 12.

Depending on the material chosen for the positioning
structure, on the manufacturing process and on the interspaces between
10 the two opposite surfaces that are aligned with the target area 22 of the
electrical pad 14, the antenna terminals 24 can be led on the microchip
protection layer 18 as shown in Figures 3 and 6, or led directly on the
positioning structure 52 or 54 as shown in Figures 8A and 8B illustrating
antenna positioning structures respectively according to a sixth and a
15 seventh illustrative embodiments of the present invention.

The sixth and seventh illustrative embodiments illustrated in
Figures 8A and 8B are respectively similar to the first and fourth
embodiments with the differences as follows. These two embodiments
20 allows to control the altitude of the antenna terminal above the microchip
surface.

The sixth embodiment results from the increase of the
material thickness of the first embodiment from h_1 to h_6 .
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The seventh embodiment results from the increase of the
material thickness of the fourth embodiment from h_4 to h_7 and from the
diminution of the interspacing of the two opposite surfaces from D_4 to D_7 .

An antenna terminal positioning structure 56 for a RFID device according to an eight embodiment of the present invention will now be described with reference to Figure 9.

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Two identical positioning structures 56 are illustrated in Figure 9. Each positioning structure 56 comprises a wall assembly in the form of a rectangular body 58 extending perpendicularly from the microchip surface 61. The rectangular body 58 is configured and 10 positioned on the surface 61 of the microchip so as to have one of its surface 60 aligned with a target area 22 over the pad 14.

The rectangular body 58 constitutes half the wall assembly 16 illustrated in Figure 1.

15

In operation, the antenna terminal 24 is moved from a first position away from the microchip 12 to a second position where it contacts the microchip surface 61 at a location between the border of the microchip surface 61 and the rectangular body 58. Then, the antenna terminal 24 is 20 swiped on (or near) the microchip surface 61 until the antenna abuts the surface 60.

This 'half' positioning structure 56 is well adapted to set the antenna terminals 24 horizontally (following the X-axis in the plane of the 25 page) onto the microchip 12.

Even though both positioning structures 56 are illustrated in Figure 9 on the left side of the bump 15 and therefore of the pad, they can

be positioned on the right side thereof the bump 15, or one on the left and the other on the right side of the respective bump 15 and pad.

Of course, to be more reliable, the body 58 is made
5 sufficiently thick (typically 1.25 to 2 times the wire diameter) compared to
the wire 24 diameter and its edges are made sufficiently sharp.

Turning now to Figure 10 a RFID microchip including two
identical terminal positioning structures for a radio-frequency identification
10 device according to a ninth illustrative embodiment of the present
invention will be described.

The positioning structure according to the ninth illustrative
embodiment of the present invention comprises a first wall assembly 16
15 identical to those illustrated in Figures 1-3, and a second wall assembly 62
made of an electrical conductive material and mounted to the small
electrical pad 14.

The second wall assembly 62 includes a wall 64 on both side
20 of a target area 66. Each wall 64 defines facing wall surfaces 68 and 68'
that are aligned with the target area 66.

Due to the small size of the contacting surface of the pad 14,
this embodiment can only be used for very fine wire diameter (25% or less
25 than pad 14 size).

Figure 11 illustrates an antenna terminal positioning
structure for a RFID device according to a tenth embodiment of the

present invention.

5 The positioning structure comprises a first wall assembly 56 similar to those illustrated in Figure 9, and a second wall assembly in the form of a wall 70 made of an electrical conductive material and mounting to the electrical pad 14. The wall 70 includes a wall surface 72 adjacent the target area 74 and on the same side as the wall assembly 56 relative to the target area 74. The wall surface 72 extends perpendicularly from the pad 14 so as to be aligned with the target area 66.

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The operation of the positioning structure according to the tenth embodiment of the present invention is identical to the operation of the eight embodiment illustrated in Figure 9.

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Turning now to Figure 12, two symmetrical antenna terminal positioning structures for a RFID device according to an eleventh illustrative embodiment of the present invention will be described.

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According to this eleventh embodiment, each positioning structure comprises a first wall assembly in the form of an triangular-shaped wall 80 made of an electrical conductive material and mounted to the electrical pad so as to extend thereof, and a second wall assembly, in the form of a semi-convex wall 82 extending from the microchip 12 surface 91 and being positioned generally perpendicularly from a surface of the first wall assembly 80 formed by one of the two even side of the triangle shaped wall 80. A portion of the microchip 12 adjacent the uneven side surface 84 of the first wall assembly 80 defines a target area 86 for the

antenna terminal 24.

More specifically, the semi-convex wall 82 is in the form of an elongated generally rectangular-shaped body including a slightly 5 convex surface 90 opposite a straight surface 89.

In operation, the antenna terminal 24 is moved from a first position away from the microchip 12 to a second position where it contacts the surface 91 of the microchip 12 between the two convex surfaces 90. 10 Then, the antenna terminal 24 is swiped on (or near) microchip surface until the antenna abuts the slightly surface convex surface 90. Then, while the portion of the antenna 24 abutting against the surface 90 is maintained in place, the free portion of the antenna 24 extending in the direction of the first wall assembly 80 is swiped in the direction of the first wall 15 assembly 80 until the antenna terminal 24 abuts the first wall assembly 80.

Figures 13 and 14 illustrate a RFID microchip 12 including two terminal positioning structures for a radio-frequency identification device according to a twelfth illustrative embodiment of the present 20 invention.

Each such positioning structure is identical to the small wall assembly 62 illustrated in Figure 10.

25 The use of the small wall assembly 62 as a positioning structure, without any positioning structure on the microchip protection layer, is suitable, for example, for products which do not require strong mechanical performances and when it is used with a very fine antenna

wire (typically 25 μ m or less).

These small structures 62 are made of an electrically conductive material since they are used for the electrical connection
5 between the microchip 12 and the antenna 24

Increasing the material thickness of the positioning structure 62 from h_{12} to h_{13} and modifying the properties of the photolithography process used to create the microchip 12 results in the positioning structure
10 92 illustrated in Figure 15.

Due to the small size of the pad 14, the manufacturing process (typically etching) to obtain sharp edge 62 can be very complex. The structure 92 provides a means to have an acceptable positioning
15 structure. The other advantage of this 'V' profile is to keep some conductive material between the pad 14 and the terminal 24, and so to have a better conductive alloy after connection process.

Typically, in photolithography process, assuming the etching
20 process is perfectly under control, a sharp edge is obtained (see Figure 14) when the ratio spacing/thickness (D/h) is greater than the minimum specified design rules.

In Figure 14, this ratio is greater than the minimum design
25 rules and we obtain sharp edges and a full etching of the positioning structures 62.

In Figure 15, the positioning material thickness (h) is

increased and/or the spacing (D) between the two internal edges is reduced. Then the ratio D_{13}/h_{13} is much lower than the minimum design rules and the typical etching process do not allow having sharp edges. One can use this design rules violation to create a specific positioning structure in 'V' on the top of positioning material 92.

5 This method is also applicable to obtain a specific topology for the additional positioning structures 52 deposited on the microchip protection layer 18 as shown in Figure 6.

10

Figure 16 illustrates a positioning structure 96 similar to the positioning structure of Figure 13 but including only one small wall assembly 62 instead of two.

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Turning now to Figures 17-19, a terminal positioning structure 98 for a radio-frequency identification device according to a fiftieth illustrative embodiment of the present invention will now be described.

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Figures 17-19 illustrate an electronic circuit in the form of a RFID microchip 12 including two conventional electrical pads 14 covered by a bump 15.

25

Two identical terminal positioning structures 98 are illustrated in Figures 17-19. In this case, the positioning structures 98 are obtained by a specific topology of the microchip protection layer 18. This specific topology is the result of a specific design (and specific etching) of the embedded layers inside the microchip 12. The protection layer 18 covers

the embedded layers and gives a smooth relief to the microchip surface, yielding two wall assemblies 100, each including two rounded rectangular wall 102.

5 The main advantage of this technique is the fact that the positioning structure 98 is made during the chip manufacturing process and then does not require any additional operation.

10 However, as the protection layer 18 is generally very strong (glassivation), a structure such as the positioning structure 98 allows only the wire positioning and not the mechanical attachment. This mechanical attachment is performed by adding a gluing material when the wire 24 is positioned.

15 Figures 20 and 21 illustrate two identical positioning structures 104. Each structure 104 is composed of two miniature pads 106 and 108. These two miniatures pads 106 and 108 are internally electrically connected. Miniatures pads 106 and 108 are placed by design to create spacing between them and are covered by a electrical conductive material
20 in order to form a positioning structure for the wire terminal 24 as better shown on figure 21.

25 Each miniature pads 106 and 108 of the dual pads 104 has a reduced size (typically 60 x 100 μm or less) to avoid increasing the microchip overall size.

 A wire or antenna terminal positioning and attachment structure according to the present invention can be placed on the

microchip at the wafer level, or at the microchip level before or during the antenna positioning. Depending of the positioning structure material and the manufacturing throughput required, the positioning structures can be placed on the microchip by different processes such as photolithography,

5 electroplating, screen printing etc.

Of course, wire positioning structures according to the present invention are applicable for microchip having one, two or several small antenna pads.

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Even though wire positioning structures according to the present invention have been illustrated in the context of RFID microchips, it can be used in other application where a small wire has to be contacted with a small electrical pad such as in micro-sensors or micro-electronic

15 machines (MEMs). More generally, the present invention can be used to position wires on pads provided on a surface of electronic circuit having various form and configuration.

Although the present invention has been described 20 hereinabove by way of preferred embodiments thereof, it can be modified without departing from the spirit and nature of the subject invention, as defined in the appended claims.